Report as of FY2009 for 2009VT44B: "Quantifying Sediment Loading due to Stream Bank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT Using Advanced GIS and Remote Sensing Technologies"

Publications

- Other Publications:
    - Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, 2010, Streambank Erosion in Chittenden County, VT: Application of Very High Resolution Remote Sensing and GIS Modeling, Lake Champlain 2010 Conference: Our Lake, Our Future, Lake Champlain Research Consortium, June 7-8, 2010, Burlington, VT.
    - Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, 2010, Quantifying Sediment Loading due to Streambank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT, Vermont Geological Society Winter Meeting, Feb. 6, 2010, Norwich, VT.

Report Follows

Annual (Interim) Report
March 1, 2009 – February 28, 2010 (Year 1)

Title: Quantifying Sediment Loading due to Stream Bank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT

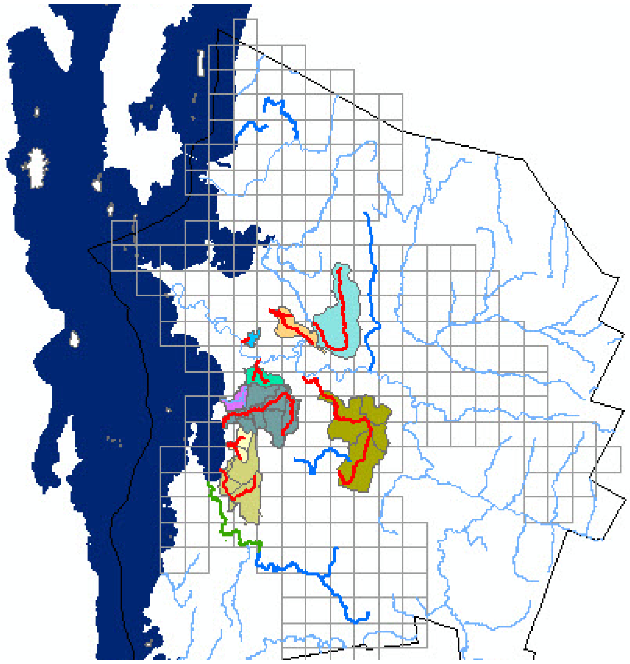
Focus Categories: Pollution, Sediments, Geomorphic Processes
Research Category: Water Quality
Start Date: March 1, 2009 End Date: February 28, 2011
Principal Investigators:

Leslie A. Morrissey, Assoc. Professor, RSENR/UVM
Donna Rizzo, Assoc. Professor, CEMS/UVM

Introduction: Streambank erosion is one of the most important but least understood nonpoint sources of sediment and phosphorus threatening the impairment of surface waters within the Lake Champlain Basin. High spatial and temporal variability and the difficulties of measuring erosion rates at watershed scales limit our understanding or the ability to quantify the contribution of streambank erosion to water quality degradation. Previous research has not provided the quantitative basis required to weight the importance of stream bank erosion relative to other sediment and P sources at watershed scales or the information needed to address within watershed variability in streambank erosion over time.

To address these issues, we have combined field data collection and remote sensing approaches to quantify sediment loading mobilized by streambank erosion in 15 Chittenden County watersheds. Three key subtasks were required to address our goal: 1) mapping of *erosion areas* due to channel migration over time with multidate imagery, 2) analysis of LiDAR-derived DEMs to quantify *streambank heights* that in turn will be used to estimate soil volume loss, and 3) estimating sediment loading per eroded feature, reach, and stream. These analyses in turn will allow us to identify critical source areas that contribute a disproportionate amount of the total sediment load to streams.

Study Area **-** Our research focused on 15 watersheds (Figure 1) in Chittenden County, VT, of which ten are on the state of Vermont's 303d list of impaired waters [VT DEC, 2008] due to urban stormwater or agricultural runoff and six, including the area draining to the non-impaired reaches of the LaPlatte River, are identified *attainment watersheds* i.e., watersheds that can be used to establish TMDL target flows for stormwater impaired watersheds having similar hydrologic and ecological characteristics. The watersheds were selected because of long-standing federal, state and public focus on in-stream sediment, phosphorus, or fecal contamination and their contribution to water quality in Lake Champlain. These watersheds were also selected to leverage available aircraft and satellite imagery, LIDAR data, VT ANR RMP fluvial geomorphic assessments, USGS and UVM stream gage stations, and our previous channel migration mapping efforts in Allen Brook and Indian Brook watersheds.



Impaired watersheds
Allen Brook
Bartlett Brook
Centennial Brook
Englesby Brook
Indian Brook (south)
LaPlatte River (west)
Morehouse Brook
Munroe Brook
Potash Brook
Sunderland Brook

Attainment watersheds
Alder Brook
LaPlatte River (east)
Patrick Brook
Streeter Brook
Sucker Brook
Trout Brook

Figure 1. Chittenden County, VT study area showing 15 watersheds under study. Stormwater impaired watersheds are shown in red, the agriculturally-impaired LaPlatte River in green, and attainment streams in bold blue. The watershed areas associated with the stormwater impaired streams are also shown. The overlying grid indicates geographic coverage of CCMPO LiDAR data (acquired in 2004).

Results: In support of efforts to map stream migration over time, USDA National Agriculture Imagery Program (NAIP) imagery and LiDAR data were acquired and compiled for all 15 streams in Chittenden County. Overhanging forest cover unfortunately precluded mapping stream centerlines with the 2008 NAIP imagery (mid-summer coverage) for all but the LaPlatte River. The remaining stream centerlines were thus mapped using available orthophotography collected during the spring leaf off period (e.g. CCMPO 1:1250 acquired in 2004). Preliminary channel migration estimates were computed as the lateral shift in stream centerlines between any two dates of observation (Figure 2) corrected for errors in image registration. Initial estimates were based on automated detection of eroded features due to lateral channel shift using ArcGIS ModelBuilder. Final estimates will require manual editing and updating of the preliminary ArcGIS model.

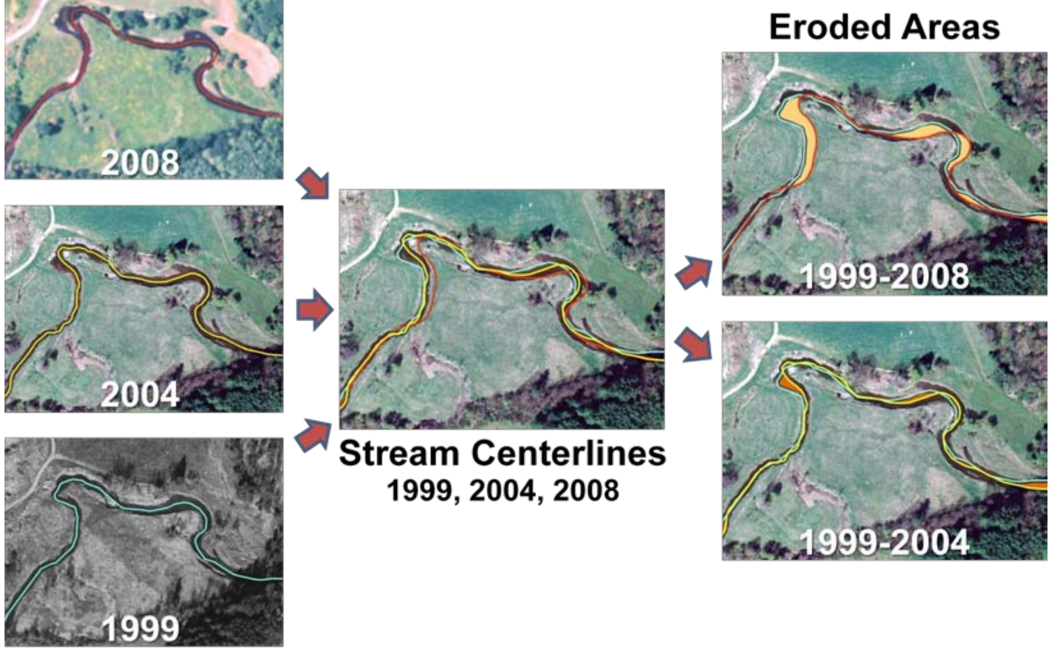


Figure 2. Stream centerlines were digitized for each image date and then overlaid to map stream migration over time (1999 – 2008).

Large spatial and temporal variability in stream migration was observed over the 1999-2008 study period as shown for the LaPlatte River (Figure 3). The number of erosion features for each reach varied from 0-65 with high variability among reaches and time intervals. The number of eroded features was highest (556) for the 2004-2008 time period, lowest (370) for 1999-2008, and intermediate (403) for the 1999-2004, respectively.

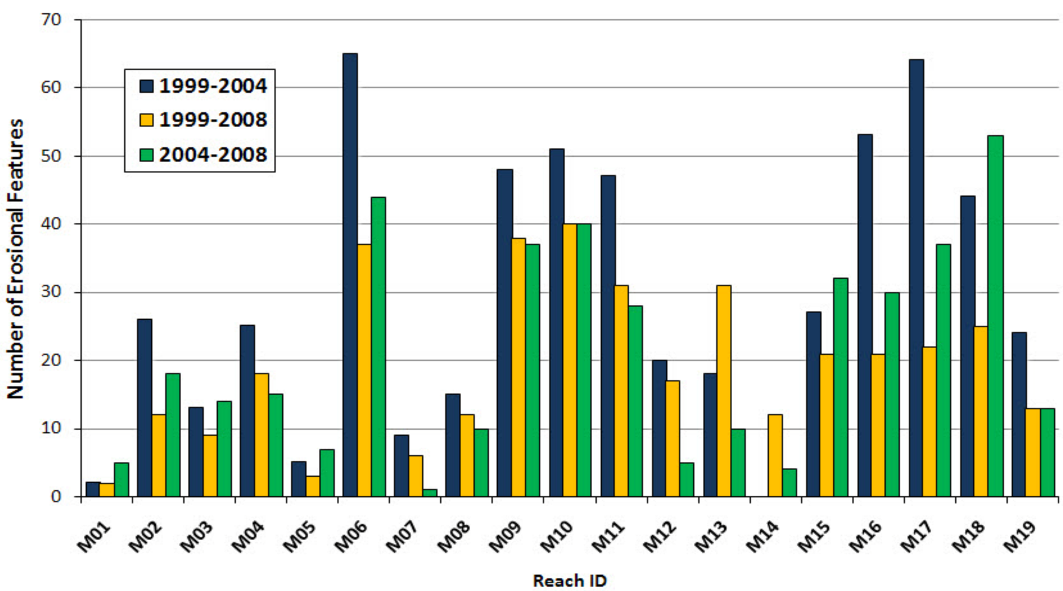


Figure 3. Number of eroded areas due to lateral stream migration summarized by reach for the LaPlatte River watershed over three time intervals (1999 – 2008).

Soil volume loss for eroded areas was calculated using LiDAR data to derive streambank and stream channel heights. For these calculations, we employed 3.2m posting bare earth (BE) and reflective surfaces (RS) LiDAR data collected over our study areas in May 2004. We derived DEMs and DSMs based on Natural Neighbor spatial interpolation and by combining BE systematic point grids with additional low lying RS points to derive the enhanced DEMs used in our subsequent processing and analyses. We then calculated an upper soil volume loss estimate as the product of the eroded area polygons derived from the multidate imagery and streambank height derived from the LiDAR elevation data.

Areal and volume estimates of soil loss differed greatly by reach within each watershed, between watersheds, and over time. Area of soil loss due to stream migration differed greatly between watersheds (Figure 4). Five of the impaired watersheds and one attainment watershed (Trout Brook) had the highest erosion rates (>10% of watershed area). Low erosion rates (<10%) were noted for the remaining impaired and attainment streams.

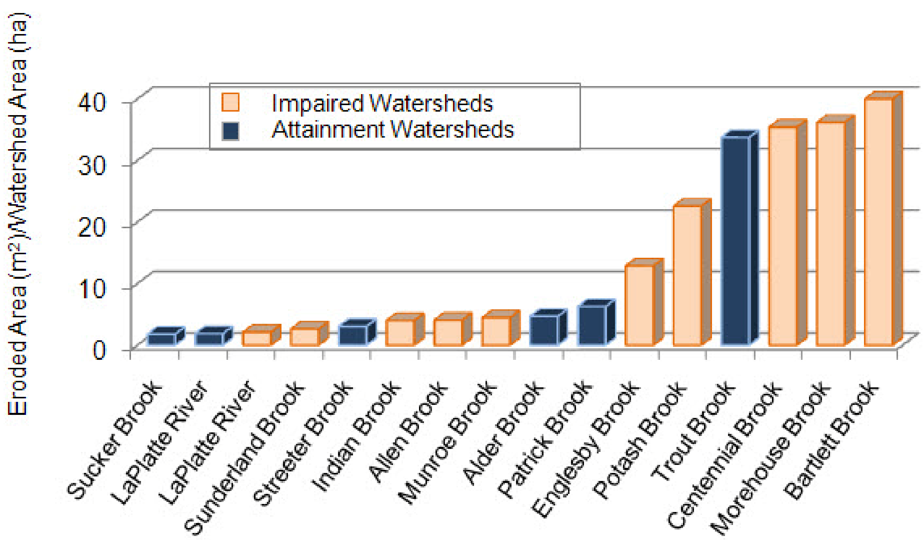


Figure 4. Streambank eroded area (1999-2004) normalized by watershed area for 15 streams in Chittenden County, VT.

The average annual rate of sediment loading (MT yr^{-1}) due to streambank erosion within each watershed over the period of study was estimated by combining measures of the volume of sediment loss derived from the remote sensing and GIS analyses with field observed soil bulk density. Soil sampling and field measures were completed in the summer of 2009 for Allen Brook at selected erosion sites as determined from the multidate imagery. Soil data included bulk density, organic matter, composition, texture and phosphorus content. In concert with D. Ross (Plant and Soil Science, UVM) and Carolyn Alves (USDA NRCS), field teams sampled 31 randomly located erosion sites (with replicates) along Allen and Indian Brooks. Additional sampling for Indian Brook will continue during the summer of 2010. Sampling along Alder Brook and LaPlatte River is also scheduled for next summer.

Preliminary estimates of sediment loading due to stream migration generated for Allen Brook and Indian Brook over the period 1999-2004 are shown in Table 1. Estimates were derived based on estimated soil volume loss and measured soil bulk density (mean 1.2, n=62). When compared to SWAT modeling to predict sediment loading in Allen Brook (Barg et al., 2003), streambank erosion accounted for approximately 13% of the total sediment loading.

Table 1. Sediment loading estimates for Allen and Indian Brooks.

Stream	Number of Reaches	Reach ID	Number of Erosion Features	Sediment Loading (MT/yr^{-1})
Allen Brook	9	M01 – M09	355	1228
Indian Brook	8	M09 - M16	244	1003

Conclusions: These preliminary results demonstrate the potential value of remote sensing to augment field surveys to quantify stream geomorphic change and sediment loading over time at watershed scales and to map and monitor stream channel changes throughout the watershed consistently, accurately, and at relatively low cost. These analyses also serve as a baseline against which future estimates of sediment loading can be evaluated and as a means to constrain subsequent P loading estimates due to streambank erosion. More importantly, this effort represents not only a significant step toward the development of a systematic approach to quantify sediment (and P) loading due to streambank erosion throughout the Lake Champlain basin and elsewhere, but also a watershed-scale approach that could greatly aid adaptive management efforts.

Student Supported: Graduate student, Ms. Kerrie Garvey, joined the project team in July 2009 under the direction of Leslie Morrissey and Donna Rizzo (anticipated graduation May 2011, M.S., Natural Resources Program, RSENR/UVM).

Conference Presentations: -

Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, Streambank Erosion in Chittenden County, VT: Application of Very High Resolution Remote Sensing and GIS Modeling, *Lake Champlain 2010 Conference: Our Lake, Our Future,* Lake Champlain Research Consortium, June 7-8, 2010, Burlington, VT.

Garvey, K.M., L. A. Morrissey, D. Rizzo, and M. Kline, Quantifying Sediment Loading due to Streambank Erosion in Impaired and Attainment Watersheds in Chittenden County, VT, *Vermont Geological Society Winter Meeting*, Feb. 6, 2010, Norwich, VT.